Fishery Data Series No. 08-51

Auke Creek Weir Studies: 2006

by

Carrie L. Hoover

October 2008

Alaska Department of Fish and Game **Divisions of Sport Fish and Commercial Fisheries**

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Department of Fish and Game	ADF&G
Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Measures (fisheries)

fork length	FL
mideye to fork	MEF
mideye to tail fork	METF
standard length	SL
total length	TL

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	e
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	E
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$\log_2$, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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ABSTRACT

A weir on Auke Creek was operated from March 1 through October 31, 2006 to count pink *Oncorhynchus gorbuscha*, chum *O. keta*, coho *O. kisutch*, and sockeye *O. nerka* salmon; steelhead *O. mykiss* and cutthroat trout *O. clarki*; and Dolly Varden *Salvelinus malma*. Age, weight and length data were collected from emigrant coho and sockeye salmon, and coded wire and passive integrated transponder (PIT) tagging were conducted on coho salmon and cutthroat trout, respectively. Length distributions were determined for emigrant cutthroat trout and Dolly Varden as well. Returning adult coho salmon were sampled for age, sex, and length data, and a length distribution was determined for immigrant cutthroat trout. A total of 4,515 coho smolts were successfully given a coded wire tag (CWT) and released downstream. An estimated 56% (SE = 2%) were age 1. and 44% (SE = 2%) were age 2. During the emigration, 208 cutthroat trout, 4,977 Dolly Varden, 25,515 sockeye smolt, 65,894 pink fry, 87 chum fry, and 36 steelhead juveniles were counted through the weir. Average fork length of emigrant Dolly Varden was 223 mm (SE = 3 mm). Fork lengths of emigrant cutthroat trout averaged 243 mm and had a SD of 42 mm. During the immigration period, 107 cutthroat trout, 2,734 Dolly Varden, 1,848 adult sockeye salmon, 13,198 pink salmon, 6,623 chum salmon, 582 adult coho salmon, and 8 juvenile steelhead were passed through the weir. Fork lengths of immigrant cutthroat trout averaged 272 mm and had a SD of 54 mm. Auke Creek contributed an estimated 313 (SE = 30) adult coho salmon to marine fisheries in 2006, yielding an exploitation rate of 35% (SE = 2.2%). Smolt-to-adult survival for the 2005 coho smolt emigration was estimated at 21% (SE = 0.7%). Counts during both the emigration and immigration periods were lower than their 26-year historical averages.

Key words: Alaska, Auke Lake, Auke Creek, cutthroat trout, Dolly Varden, steelhead, coho salmon, sockeye salmon, pink salmon, chum salmon, smolt, sea-run, weir, length distribution, timing, PIT, CWT, tag retention, exploitation, survival.

INTRODUCTION

The Alaska Department of Fish and Game, Division of Sport Fish (ADF&G), the University of Alaska, Fairbanks (UAF), and the National Marine Fisheries Service (NMFS) cooperatively fund and operate the NMFS Auke Creek weir on the outlet of Auke Lake, near Juneau, Alaska (Figure 1). The weir is a permanent structure designed to capture all emigrant and immigrant fish at Auke Creek. It is operated from March 1 to about June 30 to intercept all emigrating species, after which time it is converted and operated through October 31 to capture immigrating salmonids.

A weir has been operated at Auke Creek since 1963 and the present permanent structure was installed during spring 1980. In 1997 further modifications were made to capture, in addition to several other species, all immigrant Dolly Varden and cutthroat trout. Since installation of the permanent structure, Auke Creek weir has provided consistent, long-term information on all emigrating and immigrating species, and it provides the most complete database for several anadromous species in Southeast Alaska (Lum and Taylor 2004).

Researchers at ADF&G, UAF, and NMFS use information gathered at the Auke Creek weir in a variety of projects aimed at understanding long-term trends. Weir counts and coded wire tag (CWT) data provide indicators for local stocks and are used by fisheries managers to assess the exploitation by and contribution to various fisheries. Studies initiated at the weir have provided important insights into developmental processes, the genetic composition of runs, marine survival estimates, life history strategies, age composition, maturity, run timing, and growth of several species present in Auke Lake and Auke Creek (Gharrett and Smoker 1991; Gharrett et al. 1999; Gilk et al. 2004; Goddard 1995; Hebert et al. 1998; Hoover 2005; Lum et al. Years 1998-2002; Lum and Taylor 2004; Neimark 1984a-b; Taylor *Unpublished*, Taylor and Lum Unpublished 1998-2005; Wang 2004). Historically, Auke Creek's long term dataset has contributed useful information to the management of local fisheries, e.g., Auke Creek coho salmon serve as a key stock evaluation system in northern Southeast Alaska. The Division of Sport Fish also uses data collected by this project to better understand sea-run life history forms of Dolly

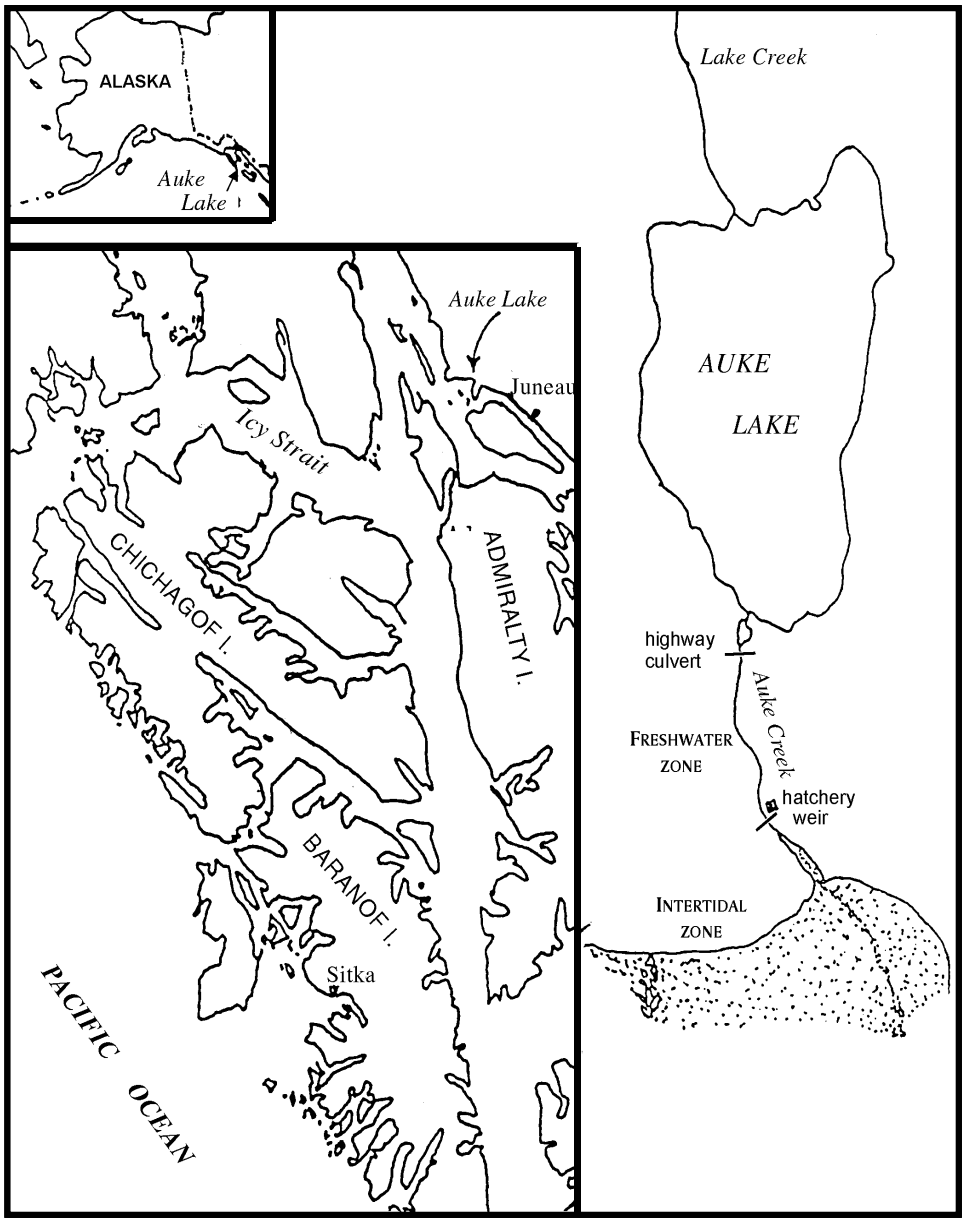

Figure 1.–The Auke Lake system in northern Southeast Alaska and location of the Auke Creek weir.

Varden and cutthroat trout and this information has contributed to several Alaska Board of Fish management decisions.

OBJECTIVES

There are two components of this project: the spring emigrant weir operated between March 1 and June 30, and the summer/fall immigrant operated between July 1 and October 31. The specific objectives, times and subsampling schemes by species are presented below.

The objectives at the Auke Creek weir between March 1 and June 30, 2006 were to:

1. Determine the length distribution of emigrant sea-run cutthroat trout.
2. Estimate the length distribution of Dolly Varden;
3. Enumerate all emigrating cutthroat trout, Dolly Varden, juvenile steelhead, sockeye smolt, pink fry and chum fry, and enumerate and CWT all emigrating coho salmon smolt;

4. Estimate length and age composition of emigrating coho salmon smolt, and estimate the number of emigrants by freshwater age; and,
5. Estimate mean weight- and length-at-age of emigrating coho salmon smolt.

The objectives between July 1 and November 1, 2006 were to:

1. Determine the length distribution of immigrating sea-run cutthroat trout;
2. Enumerate all immigrating cutthroat trout, Dolly Varden, juvenile steelhead, sockeye, pink, chum, and coho adults, and estimate sex composition of immigrant pink salmon;
3. Estimate length, age, and sex composition of immigrating coho salmon adults and jacks, and estimate the number of immigrants by age class; and,
4. Estimate the marine harvest, total abundance, smolt-to-adult marine survival, and exploitation rate of adult coho salmon bound for Auke Creek in 2006.

STUDY AREA

Auke Lake is located approximately 19.2 km north of Juneau, Alaska (53°23′, 134°37′), on the Juneau road system (Figure 1). It is 1.6 km long and 1.2 km wide and has a surface area of approximately 67 ha. The lake is fed by five tributaries, drains a mainland watershed of approximately 1072.5 ha, and its biggest tributary, Lake Creek, drains 647.5 ha. Auke Lake's depth is 31.4 m, and it has an elevation of approximately 19.1 m. The lake bottom is primarily mud with gravel areas off the inlet streams. The shoreline of the lake is bordered by forested terrain that varies from gentle slopes to steep-sided banks, and the shoreline zone consists of areas dominated by emergent vegetation of *Equisetum* spp. and *Nuphar* spp. Other areas of the lake are characterized by large numbers of submerged and floating conifers anchored to the lakeshore and bottom by root wads. At least 50% of the shoreline has been urbanized by residential development (Lum and Taylor 2004).

Auke Creek is the outlet of Auke Lake. The weir on Auke Creek is located above mean tide level and about 400 m downstream from the outlet of Auke Lake. On average, Auke Creek supports annual migrations of about 700 coho salmon adults, 6,000 coho smolts, 3,400 sockeye salmon adults, and 16,900 sockeye smolts (Table 1). The Auke Lake system also supports migrating populations of about 5,000 Dolly Varden and 225 cutthroat trout (Table 1). The lake is closed to retention of sport-caught Dolly Varden, but it supports a small sport fishery for cutthroat trout. Cutthroat trout are caught through the ice during the winter and from the beach or small boats during the remainder of the year. Anecdotal information suggests that the trout fishery in Auke Lake was once more productive than at present. The emigration of adult cutthroat from Auke Lake initially increased as enhancement efforts occurred in the lake (Lum and Taylor 2004), but migration numbers have been declining since 1996.

METHODS

EMIGRANT POPULATIONS

The Auke Creek weir was operated from March 1 through June 22, 2006 to intercept all emigrant salmonids. During this time fish could not move upstream through the weir. The weir is designed

Table 1.–Average number of all migrating species counted at Auke Creek; spring and fall averages calculated from 1980–2005 immigrants and emigrants. Counts in italics represent smolt; others represent adults.

Migration period	Pink salmon	Coho salmon	Sockeye salmon	Chum salmon	Chinook salmon	Dolly Varden	Cutthroat trout	Juvenile Steelhead
Spring	*107,834*	*6,048*	*16,927*	*4,786*	-	6,110	251	*11*[a]
Fall	10,958	721	3,399	1,244	227[b]	4,111[c]	218[c]	6[c]

[a] Average of 1990–2005 weir counts when this species was tallied.

[b] Average of 1987–2005 weir counts; these (presumed hatchery strays) are killed at the weir.

[c] Average of 1997–2005 weir counts when these species were tallied.

so that water spills through five inclined traps and vertical aluminum panels covered with 3 mm perforations that are effective at both high and low flows. Fish that exited the inclined traps were diverted through an aluminum trough to a fiberglass holding tank. Fish were sorted by species, counted, sampled, and released each day downstream of the weir.

All emigrating cutthroat trout were counted, measured to the nearest mm FL, examined for external marks or tags, and checked for passive integrated transponder (PIT) tags. Fish that were not tagged had a PIT tag inserted just posterior to the cleithrum and received an adipose clip as a secondary mark to evaluate tag loss. All emigrating Dolly Varden were counted, and length composition was estimated using a systematic sampling procedure where every 10^{th} Dolly Varden passed downstream was measured to the nearest mm FL. The sample was taken by holding (placing in a basket) the 1^{st}, 11^{th}, 21^{st}, etc. fish passed downstream; selected fish were measured after all fish were counted for the day. No conscious effort was made to select a fish by size. Dolly Varden and cutthroat trout mortalities found in the traps or on the weir were noted separately and included in the daily total. Cutthroat mortalities were sampled for otoliths, length, scales, sex, and the PIT tag, if present, was removed. Emigrating steelhead juveniles were also counted and measured for FL to the nearest mm.

Salmon smolts emigrating from Auke Creek were counted daily. Each captured coho salmon smolt was anesthetized in a solution of MS-222, injected in the snout with a full-length (1 mm) CWT, and marked by excising the adipose fin. Each week, a sample of coho smolt captured on one or more days was re-anesthetized, weighed to the nearest 0.01 g, measured for length to the nearest mm FL, scale sampled, and released downstream below the weir the following morning after being tested for tag retention. Either every smolt was sampled or a systematic (1 in x) procedure was used. Overall goals were to sample 75 to 175 fish per sample day, and to maintain an approximately proportional sample over time such that at least 300 fish were sampled. Scales were collected from the preferred area (Scarnecchia 1979) and sandwiched between two microscope slides that were taped together and labeled with location and sample date. Scales were then aged at a later time.

Sockeye salmon smolts were collected, anesthetized, weighed, measured, and sampled for scales in the same manner as coho smolt. There is no aging of sockeye scales at the current time, but they are collected for possible aging at a later date. Pink and chum salmon fry were also counted daily, and 50 pink salmon fry were collected every Monday, anesthetized with MS-222, weighed, measured for length (mm), and upon recovery, released downstream from the weir. Chum salmon fry were not measured or weighed.

IMMIGRANT POPULATIONS

The upstream weir was installed on June 22 and operated through October 31, 2006 to intercept and count all immigrating adult pink, chum, sockeye, and coho salmon, as well as cutthroat and juvenile steelhead trout, and Dolly Varden. Adult Chinook salmon *O. tshawytscha* from releases of hatchery smolts in Auke Bay near the mouth of Auke Creek also returned during the immigration period. Because these are not indigenous to Auke Creek, they were counted by maturity (adult or jack, where jacks are defined as age-.0 fish) and killed at the weir.

The upstream weir was modified by installing vertical slotted aluminum panels (90 x 178 cm) into the structure to divert fish into the adult trap without restricting water flow. This allowed all fish moving upstream to be captured while blocking any downstream movement. Trout screens (45 x 90 cm) made out of perforated aluminum (1.5 x 10 cm) were also added to the slotted weir panels on the upstream side to prevent the movement of smaller-sized fish. Small fish migrating upstream were caught not only in the adult trap, but in two trout traps as well. These traps measured 1.5 x 2.4 x 0.8 m high and were attached to the upstream side of the weir. Pickets spaced 2.5 cm apart prevented larger salmonids from entering them. Plastic mesh netting (6 x 6 mm) was used to cover the walls of the trout traps, as well as the adult trap, to retain smaller fish.

All immigrating steelhead trout and Dolly Varden were counted and examined for external marks or tags prior to release upstream. Steelhead trout were also measured to the nearest mm FL. All

cutthroat trout were counted, measured, and examined for external marks and the presence of a PIT tag. All cutthroat mortalities were sampled for otoliths, length, scales and sex, and the PIT tag removed if present.

All adult (≥age-.1) and jack (age-.0) sockeye and coho salmon passing the weir were counted, examined for external marks, and released upstream. Length (nearest mm MEF) and sex were recorded, and scales were collected from a target 40 to 120 fish sampled on one or more days per week. Targets within sample days were to either sample every adult or adopt a systematic (1 in x) procedure. Overall sampling goals were to maintain an approximately proportional sample over time such that about 250 or more fish of each species were sampled. Adult coho salmon were stunned in an electroshock basket prior to sampling. Scales from jacks and adults (4 per fish) were collected from the preferred area and placed on a gum card. Scales were pressed onto acetate cards and analyzed for age using a microfiche reader. Length, sex and heads were collected from adipose-clipped coho mortalities collected on the weir. All heads collected from adipose-clipped coho were dissected and CWTs were removed and deciphered at the Auke Creek hatchery facility.

Adult pink and chum salmon returning to Auke Creek were counted, examined for marks and released upstream. The sex of all pink salmon adults was determined and the number of each sex was counted. There were no hatchery returns to Auke Creek in 2006, however, marked pink salmon will be returning in future years as part of University of Alaska Fairbanks research projects.

MARINE FISHERIES SAMPLING

Adult coho are harvested in various fisheries as they return to spawn. Recovery of tagged fish from troll, purse seine, and gillnet fisheries is done by ADF&G Division of Commercial Fisheries port samplers, while the Division of Sport Fish creel survey program recovers tagged fish from sport fisheries. Recoveries of CWTs from adult coho salmon (identified by missing adipose fins) in sampled sport and commercial fisheries in 2006 were used to estimate the contribution of Auke Lake fish to these fisheries using methods described in Bernard and Clark (1996).

Commercial catch data for the analysis was summarized by ADF&G statistical week and district (for gillnet and seine fisheries), or by period and quadrant for troll fisheries. Sport fish CWT recovery data were obtained from ADF&G Mark, Tag and Age Laboratory reports and summarized by biweek and fishery (e.g., biweek 16 during the Juneau Marine Creel Survey). Harvest estimates were obtained from ADF&G reports (e.g., Suchanek and Bingham 1992) and ADF&G computer summaries.

DATA ANALYSIS

Age, Length, and Sex Composition

Length composition of the emigrant Dolly Varden population passing the weir was estimated by:

$$\hat{p}_\ell = \frac{n_\ell}{n} \tag{1}$$

$$\mathrm{var}(\hat{p}_\ell) = \left[1 - \frac{n_\ell}{N}\right] \frac{\hat{p}_\ell(1-\hat{p}_\ell)}{n_\ell - 1} \tag{2}$$

where $\hat{p}_\ell$ is the estimated proportion of the population in length group ℓ, n is the number of fish measured in the systematic (1 in 10) sampling, n_ℓ is the subset of n belonging to group ℓ, and N is the total weir count. A finite population correction factor (fpc) = (1 - n_ℓ / N) is included because the population total is known and the sampling rate is relatively high. As all cutthroat trout were measured, size composition of cutthroat emigrants was known and did not need to be estimated.

Abundance of Dolly Varden in each length group in the population ($\hat{N}_\ell$) was estimated:

$$\hat{N}_\ell = \hat{p}_\ell N \tag{3}$$

$$\mathrm{var}(\hat{N}_\ell) = N^2 \mathrm{var}(\hat{p}_\ell) \tag{4}$$

Age composition ($\hat{p}_a$) of the migrant coho salmon (smolt, adult, and jack) populations passing the weir were estimated using a temporally stratified sampling design:

$$\hat{p}_{a,h} = \frac{n_{a,h}}{n_h} \tag{5}$$

$$\mathrm{var}(\hat{p}_{a,h}) = \left[1 - \frac{n_h}{N_h}\right] \frac{\hat{p}_{a,h}\left(1 - \hat{p}_{a,h}\right)}{n_h - 1} \quad (6)$$

$$\hat{p}_a = \frac{1}{N}\sum_h N_h \ \hat{p}_{a,h} \quad (7)$$

$$\mathrm{var}(\hat{p}_a) = \sum_h W_h^2 \mathrm{var}(\hat{p}_{a,h}) \quad (8)$$

Where $\hat{p}_{a,h}$ is the estimated proportion of the population in age group *a* and temporal strata *h*, n_h is the number of fish successfully aged in strata *h*, $n_{a,h}$ is the subset of n_h belonging to group *a*, and N_h is the total count at the weir in stratum *h*. Sampling weights were defined as $W_h = N_h / N$, and $N = \sum N_h$. Strata were defined as weeks. Abundance at age $\hat{N}_a$ was estimated as in (3) and (4), using $\hat{p}_a$ rather than $\hat{p}_\ell$.

Sex composition in each age group was estimated using the same temporally stratified design:

$$\hat{p}_{a,sex,h} = \frac{n_{a,sex,h}}{n_{a,h}} \quad (9)$$

$$\mathrm{var}(\hat{p}_{a,sex,h}) = \left[1 - \frac{n_{a,h}}{\hat{N}_{a,h}}\right] \frac{\hat{p}_{a,sex,h}\left(1 - \hat{p}_{a,sex,h}\right)}{n_{a,h} - 1} \quad (10)$$

$$\hat{p}_{a,sex} = \frac{1}{\hat{N}_a}\sum_h \hat{N}_{a,h} \ \hat{p}_{a,sex,h} \quad (11)$$

$$\mathrm{var}(\hat{p}_{a,sex}) \approx \sum_h \hat{W}_{a,h}^2 \mathrm{var}(\hat{p}_{a,sex,h}) + \frac{\sum_h \mathrm{var}(\hat{N}_{a,h})\left(\hat{P}_{a,sex,h} - \hat{P}_{a,sex}\right)^2}{\hat{N}_a{}^2} \quad (12)$$

where ($\hat{p}_{a,sex,h}$) is the estimated proportion being sex = male or sex = female at age *a* in strata *h*, $n_{a,h}$ is the number of age *a* fish successfully sexed in strata *h*, $n_{a,sex,h}$ is the subset of $n_{a,h}$ being male or female, and $\hat{N}_{a,h}$ is calculated as in (3), but by stratum using (5) and N_h. Because sampling weights are estimated, variance (12) was approximated using the delta method (Seber 1982; Zar 1999).

Abundance by age and sex was calculated

$$\hat{N}_{a,sex} = \hat{p}_a \ \hat{p}_{a,sex} \ N \quad (13)$$

$$\mathrm{var}(\hat{N}_{a,sex}) \approx N^2[\hat{p}_a^2 \mathrm{var}(\hat{p}_{a,sex}) + \hat{p}_{a,sex}^2 \mathrm{var}(\hat{p}_a) - \mathrm{var}(\hat{p}_{a,sex})\mathrm{var}(\hat{p}_a)] \quad (14)$$

Equivalently, the product $\hat{p}_a \ \hat{p}_{a,sex}$ in (13) could simply be defined as $\hat{p}_{a,sex}$ = the proportion at age and sex, and (14) would simplify accordingly (setting $\mathrm{var}(\hat{p}_a) = 0$). Mean lengths and weights of coho migrants at age were also estimated using the temporally stratified design. For length at age (ℓ_a), where i denotes an individual fish,

$$\hat{\bar{l}}_{a,h} = \frac{1}{n_{a,h}}\sum_i l_{a,h,i} \quad (15)$$

$$\mathrm{var}\left(\hat{\bar{l}}_{a,h}\right) = \left[1 - \frac{n_{a,h}}{\hat{N}_{a,h}}\right] \sum_i \frac{\left(l_{a,h,i} - \hat{\bar{l}}_{a,h}\right)^2}{n_{a,h}\left(n_{a,h} - 1\right)} \quad (16)$$

$$\hat{\bar{l}}_a = \frac{1}{\hat{N}_a}\sum_h \hat{N}_{a,h} \ \hat{\bar{l}}_{a,h} \quad (17)$$

$$\mathrm{var}(\hat{\bar{l}}_a) \approx \sum_h \hat{W}_{a,h}^2 \mathrm{var}\left(\hat{\bar{l}}_{a,h}\right) + \frac{\sum_h \mathrm{var}(\hat{N}_{a,h})\left(\hat{\bar{l}}_{a,h} - \hat{\bar{l}}_a\right)^2}{\hat{N}_a^2} \quad (18)$$

where $n_{a,h}$ is the number of age *a* fish successfully measured in strata *h*. Equations 15–18 above were modified for estimating mean lengths and weights at age by sex, by adding notation for sex (i.e., $\ell_{a,sex,h,i}$, $\hat{\bar{\ell}}_{a,sex,h}$, $\hat{\bar{\ell}}_{a,sex}$, $n_{a,sex,h}$, $\hat{N}_{a,sex,h}$, $\hat{N}_{a,sex}$, $\hat{W}^2{}_{a,sex,h}$). Mean lengths and weights without respect to age by sex were also computed; in this case notation for age (*a*) is dropped, N_h, *N*, and

W_h are not estimates (as in equations 6-8), and the very rightmost term in (18) is dropped.

Marine Harvest, and Adult Return, Survival and Exploitation

Because all smolt emigrating from Auke Creek were presumed marked with a CWT, we assumed all returning jacks and adults that originated from Auke Creek had been tagged (and marked with a adipose finclip) when estimating harvest. The fraction of jacks (from 2005) and adults (in 2006) passing the weir with an adipose finclip were used to evaluate this assumption. Any unmarked, mature coho salmon captured at the weir were treated as strays from nearby hatchery enhancement efforts and from streams with natural production.

Total abundance of adult coho salmon returning to Auke Creek was calculated by summing the estimated marine harvest and the escapement of adipose-clipped and CWT-marked fish counted through the weir,

$$\hat{N}_R = \hat{T} + N_e \tag{19}$$

$$\mathrm{var}\left(\hat{N}_R\right) = \mathrm{var}\left(\hat{T}\right) \tag{20}$$

where $\hat{N}_R$ is the estimated abundance of adult coho salmon returning to Auke Creek, N_e is the escapement count of adult coho returning to Auke Creek in 2006, and $\hat{T}$ is the estimated marine harvest of adult Auke Creek coho salmon in 2006.

Smolt-to-adult marine survival $\hat{S}$ was calculated by dividing the estimated total adult abundance by the number of coho salmon smolts that were counted, tagged, and released alive in 2005,

$$\hat{S} = \frac{\hat{N}_R}{C} \tag{21}$$

$$\mathrm{var}\left(\hat{S}\right) = \left(\frac{1}{C}\right)^2 \mathrm{var}\left(\hat{N}_R\right) \tag{22}$$

where C is the number of smolt counted, tagged, and released alive from Auke Creek in 2005.

The exploitation rate $\hat{E}$ for adult coho salmon was calculated by:

$$\hat{E} = \frac{\hat{T}}{\hat{N}_R} \tag{23}$$

$$\hat{\mathrm{var}}\left(\hat{E}\right) = \frac{\hat{\mathrm{var}}\left(\hat{T}\right) N_e^2}{\hat{N}_R^4} \tag{24}$$

RESULTS

MIGRANT CUTTHROAT TROUT

A total of 208 cutthroat trout emigrated in 2006 (Table 2, Figure 2). This count was higher than that of the previous 2 years and close to the 26-year average of 251 (Table 1, Figure 3). The first emigrant was captured on April 9 and the last on June 17 (Appendix A1). The midpoint of emigration (date on which 50% of fish passed the weir) was May 25.

Of these 208 emigrant cutthroat trout, 30 were missing adipose fins and 178 were not marked or tagged. Only 27 of the 30 fish missing an adipose fin had a PIT tag, suggesting a 10% rate of PIT tag loss. Of the 178 unmarked fish, 41 (23%) had red dye marks on their anal fins, indicating that they were sea-run fish seen at the weir the previous fall. Fork lengths for emigrants averaged 243 mm, had a SD of 42 mm, and ranged in size from 149 to 408 mm (Table 2, Figure 4). Length of emigrants declined over time (Figure 5).

A total of 107 cutthroat trout immigrated into Auke Creek in fall 2006 (Table 2, Figure 2). Approximately half (50) of the immigrants appeared to be "new" to the system as they displayed no external marks or PIT tags. Of 57 adipose-clipped fish captures, 56 had an operating PIT tag.

Even though cutthroat trout appeared in the upstream trap much earlier in the season, the first fish was not allowed to immigrate until September 14 (Appendix A2) because some cutthroat trout are not ready to remain in freshwater when captured at the weir early in the immigration. This leads to biased upstream run timing data, but there is no way to avoid this as releasing fish above the weir too early results in high mortality (Lum and Taylor 2004). Fork length on immigrant cutthroat trout averaged 272 mm, had a SD of 54 mm, and ranged

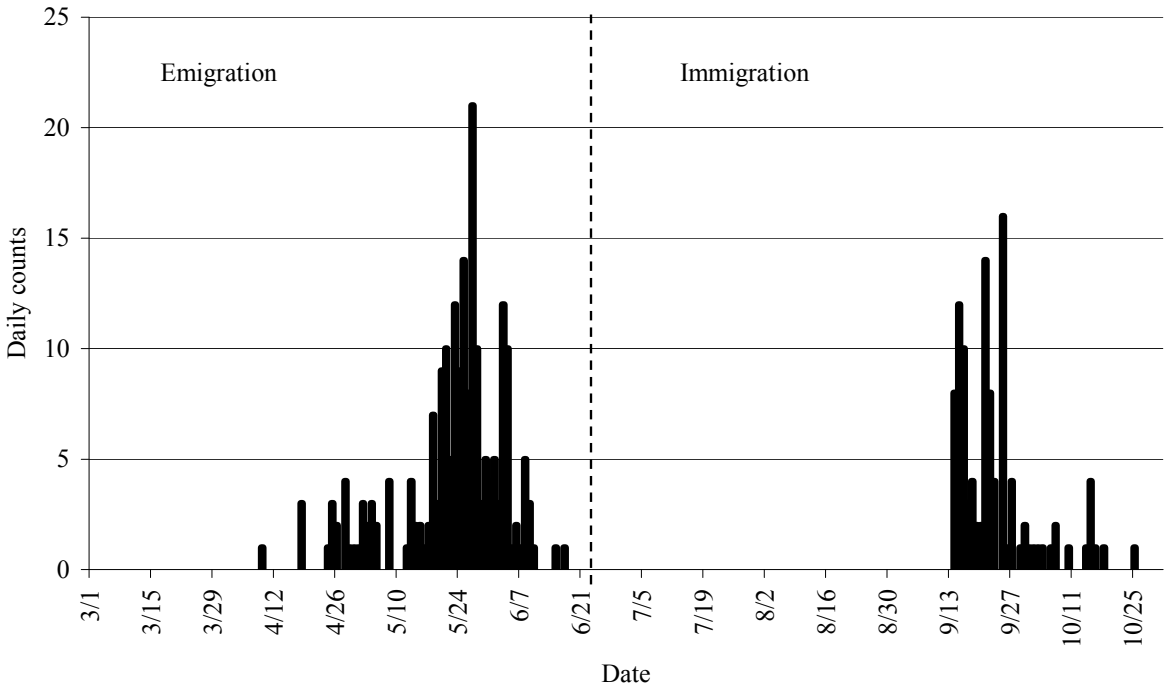

Figure 2.–Spring emigration and fall immigration counts for cutthroat trout at Auke Creek in 2006.

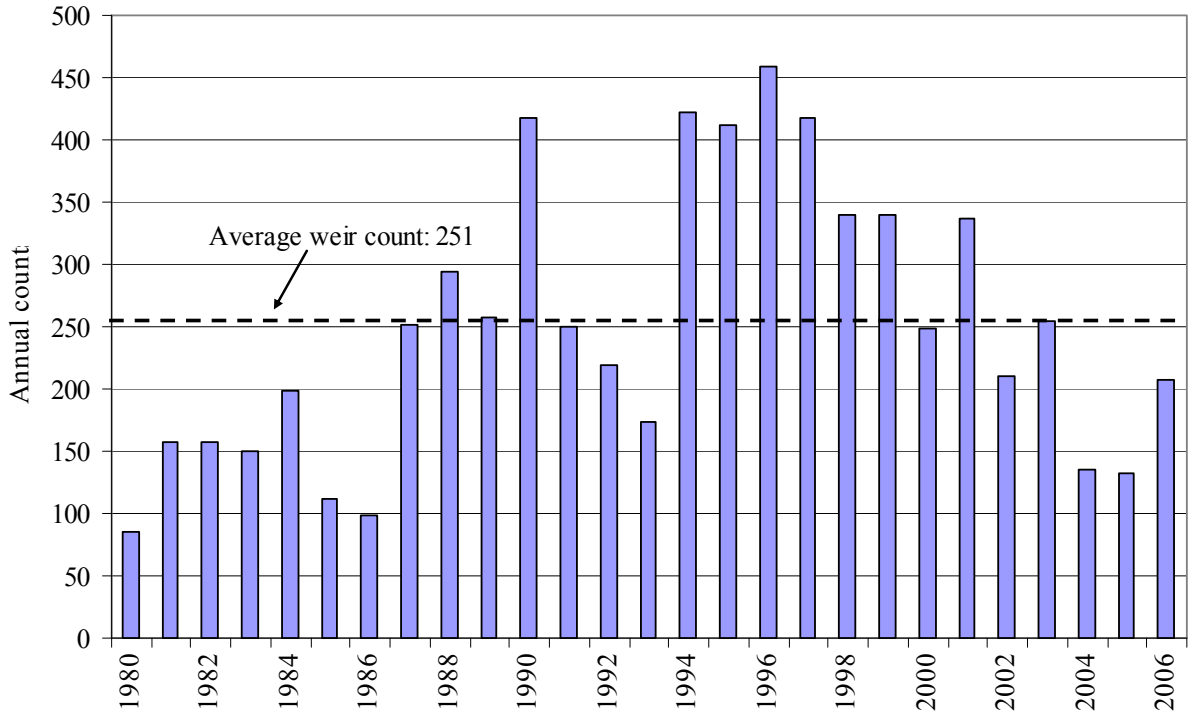

Figure 3.–Annual emigration counts of cutthroat trout at Auke Creek, 1980–2006.

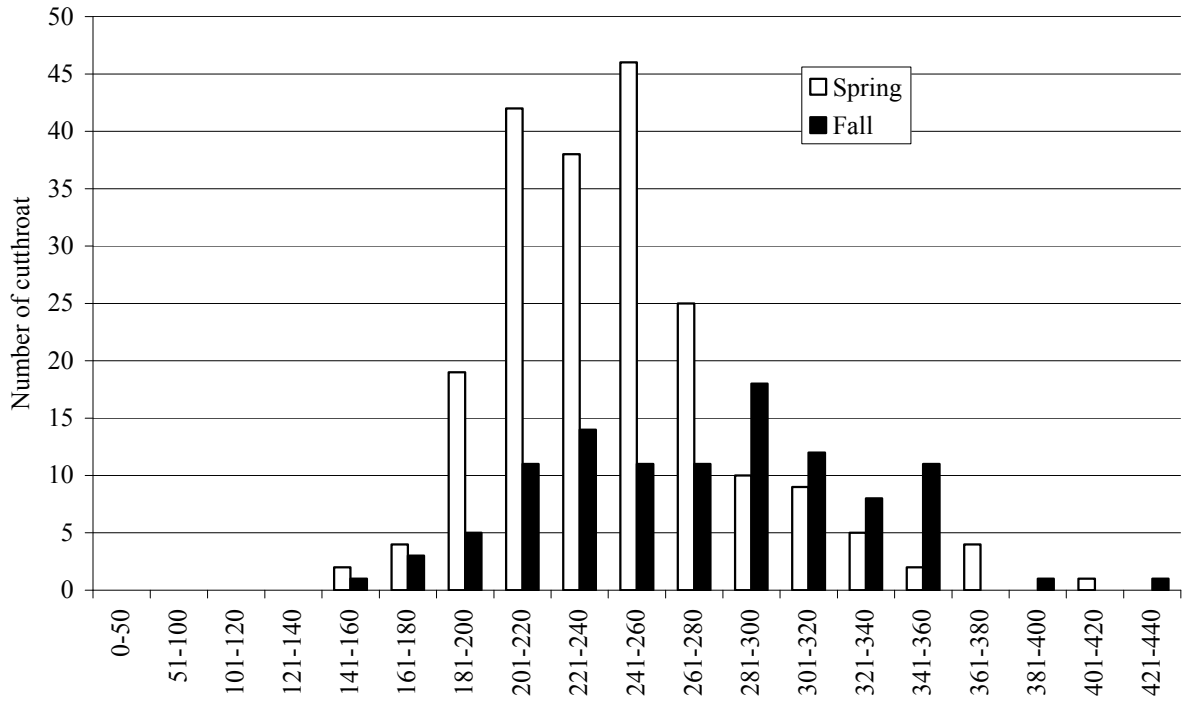

Figure 4.–Lengths of cutthroat trout, pooled by 20 mm groups, during the spring emigration and the fall immigration at the Auke Creek weir in 2006.

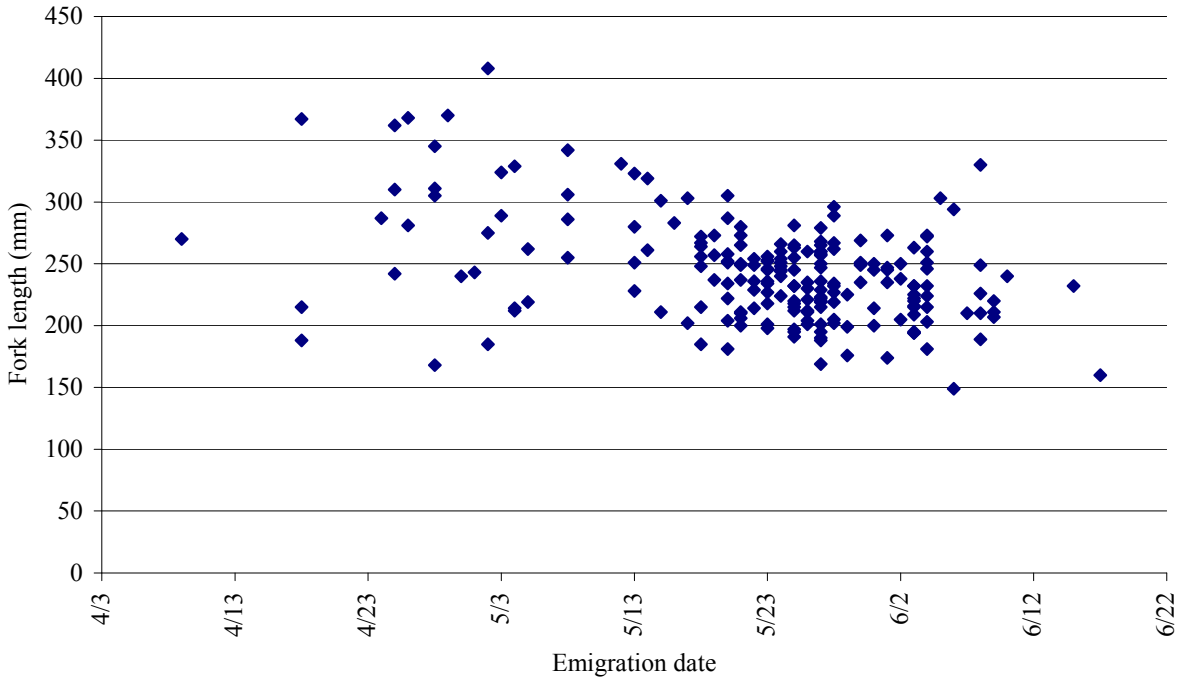

Figure 5.–Cutthroat trout lengths versus emigration date at Auke Creek in 2006.

Table 2.–Length composition of emigrant and immigrant cutthroat trout at Auke Creek in 2006.

Length, mm FL	Spring emigrants	Fall immigrants
< 120	0	0
121–140	0	0
141–160	2	1
161–180	4	3
181–200	19	5
201–220	42	11
221–240	38	14
241–260	46	11
261–280	25	11
281–300	10	18
301–320	9	12
321–340	5	8
341–360	2	11
361–380	4	0
381–400	0	1
401–420	1	0
421–440	0	1
n =	207[a]	107

[a] 1 fish not measured.

in size from 153 to 438 mm (Table 2, Figure 4). There was on trend in the length of immigrants over time (Figure 6).

Growth rates were determined for PIT-tagged cutthroat trout that emigrated from and then immigrated back into Auke Creek in 2006. Because immigration data were biased by not allowing fish to move upstream prior to September 14, relationships between emigration and immigration timing and between emigration date and length of marine residence are not reported. The average hiatus of these fish was 122 d (SD = 16 range = 97-170 d). Average growth during the hiatus was 66 mm (SD = 20 mm) and ranged from 27 to 107 mm. The average growth rate during the hiatus was 0.548 mm/d (SD = 0.176), and the growth rate tended to decrease as the size of the fish got larger (Figure 7).

MIGRANT DOLLY VARDEN

A total of 4,977 Dolly Varden emigrated in 2006, and even though this count is higher than the two previous years, it is still below the 26-year average of 6,110 (Table 1, Figure 8). The first Dolly Varden was captured on March 28 and the last on June 18 (Appendix A1); the midpoint of emigration occurred on May 13 (Figure 9). Average fork length of emigrating Dolly Varden was 223 mm

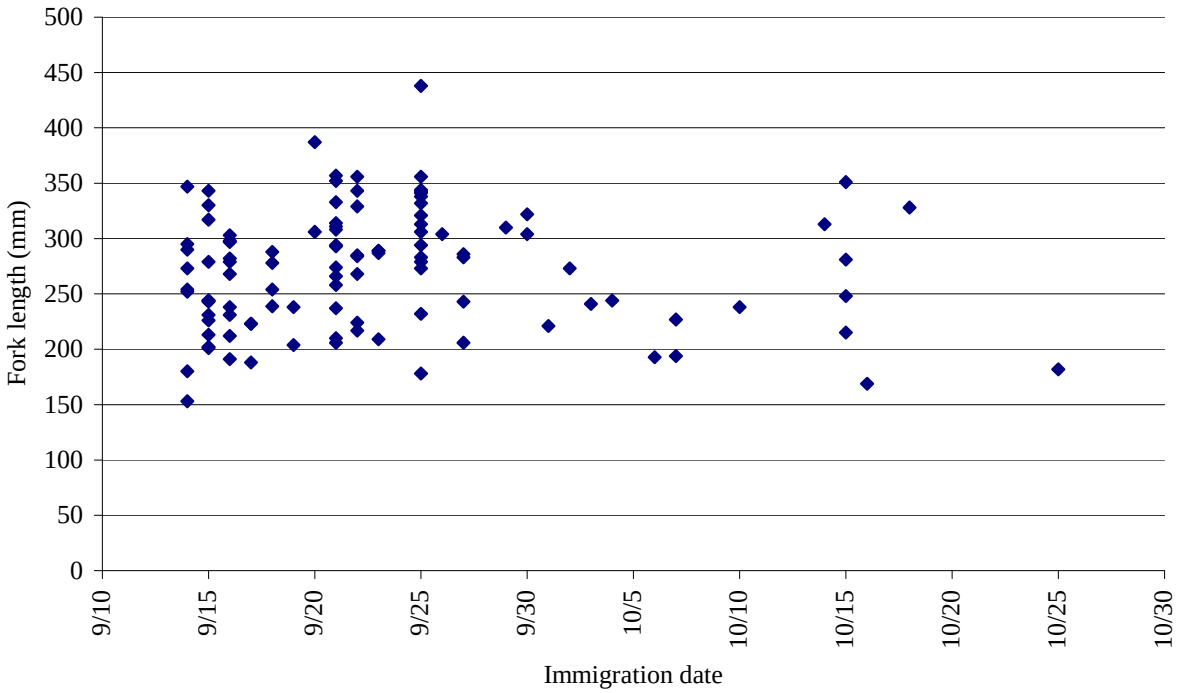

Figure 6.–Cutthroat trout lengths versus immigration date at Auke Creek in 2006.

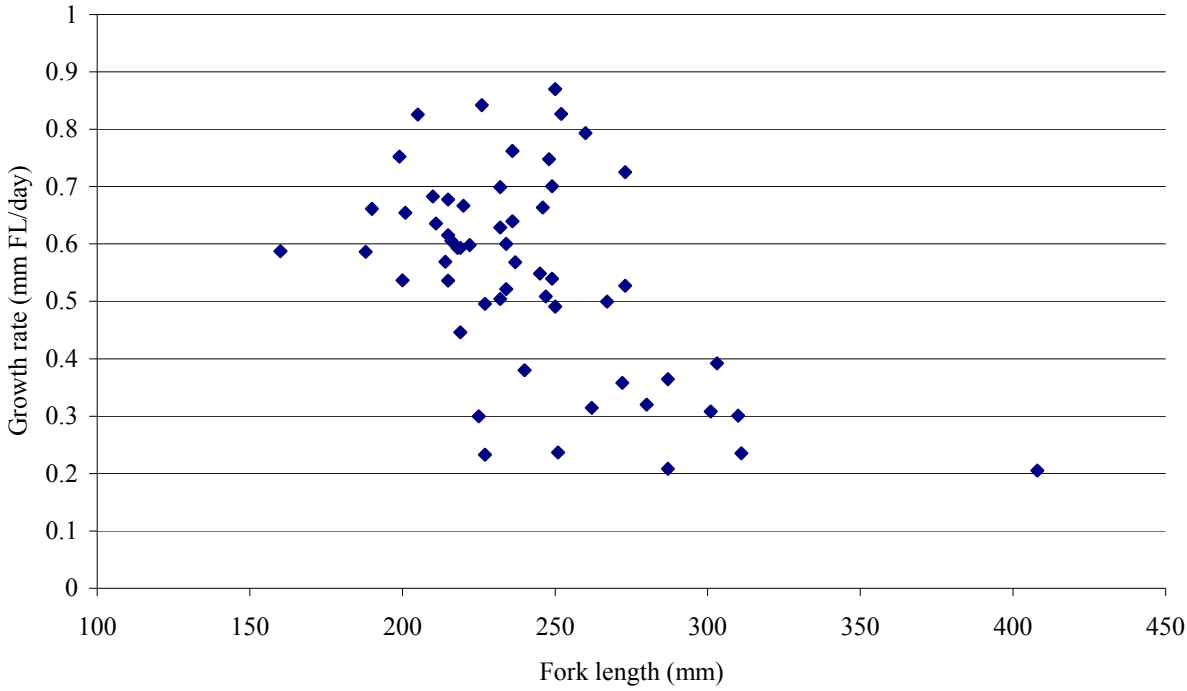

Figure 7.–Growth rate of tagged cutthroat trout between emigration and immigration in 2006 versus length at emigration from Auke Lake.

(SE = 3 mm) and ranged from 85 to 440 mm (n = 514). Length of emigrants declined over time (Figure 10). The estimated length composition of the emigration suggests that less than 12% of the run was over 300 mm (Table 3, Figure 11), which is the smallest length at which Dolly Varden are estimated to be mature (ADF&G 1994).

The Dolly Varden immigration began on June 27 and lasted until October 29 (Appendix A2). A total of 2,734 Dolly Varden immigrated in 2006, and the midpoint of the immigration occurred on September 2 (Figure 9). This was below the nine-year average of 4,111 (Table 1) and was the second lowest number of Dolly Varden counted upstream through the weir.

SALMON SMOLT COUNTS, CODED WIRE TAGGING, AGE, WEIGHT, AND LENGTH

Coho smolt began their emigration from Auke Creek on May 4, 2006. The migration lasted through June 22 (Appendix A1), and its midpoint was May 24. A total of 4,532 coho smolt were captured, 4,515 of which were successfully released downstream with a CWT and adipose finclip. This is less than the 26-year historical average of 6,048 (Table 1) and is the fifth lowest number of fish seen during that time.

An estimated 56% of coho smolts emigrating in 2006 were age 1. and 44% were age 2. The mean length and weight for all smolts sampled was 115 mm (SE = 0.9 mm) and 15 g (SE = 0.38 g, Table 4). Age-1. smolts averaged 105 mm (SE = 0. 7 mm) and 11 g (SE = 0.21 g), while age-2. smolts averaged 128 mm (SE = 1.1 mm) and 20 g (SE = 0.64 g, Table 4). Age-1. smolt lengths ranged from 83 to 126 mm, and age-2. smolt lengths ranged from 100 to 173 mm (Figure 12). The weight of age-1. smolt ranged from 5 to 21 g, while the weight of age-2. smolt ranged from 10 to 49 g (Figure 13).

Sockeye smolt began their emigration from Auke Creek on April 29, 2006. The migration lasted through June 21 (Appendix A1), and its midpoint was May 26. A total of 25,515 sockeye smolt

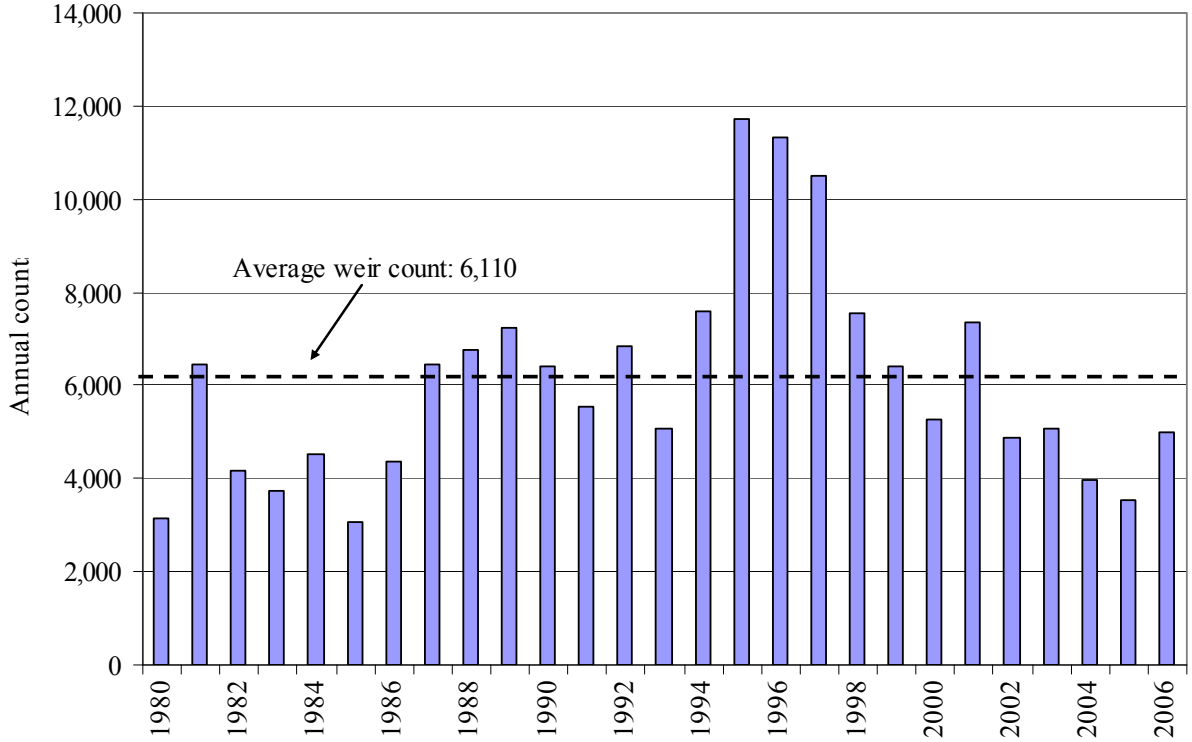

Figure 8.–Annual emigration counts of Dolly Varden at Auke Creek, 1980–2006.

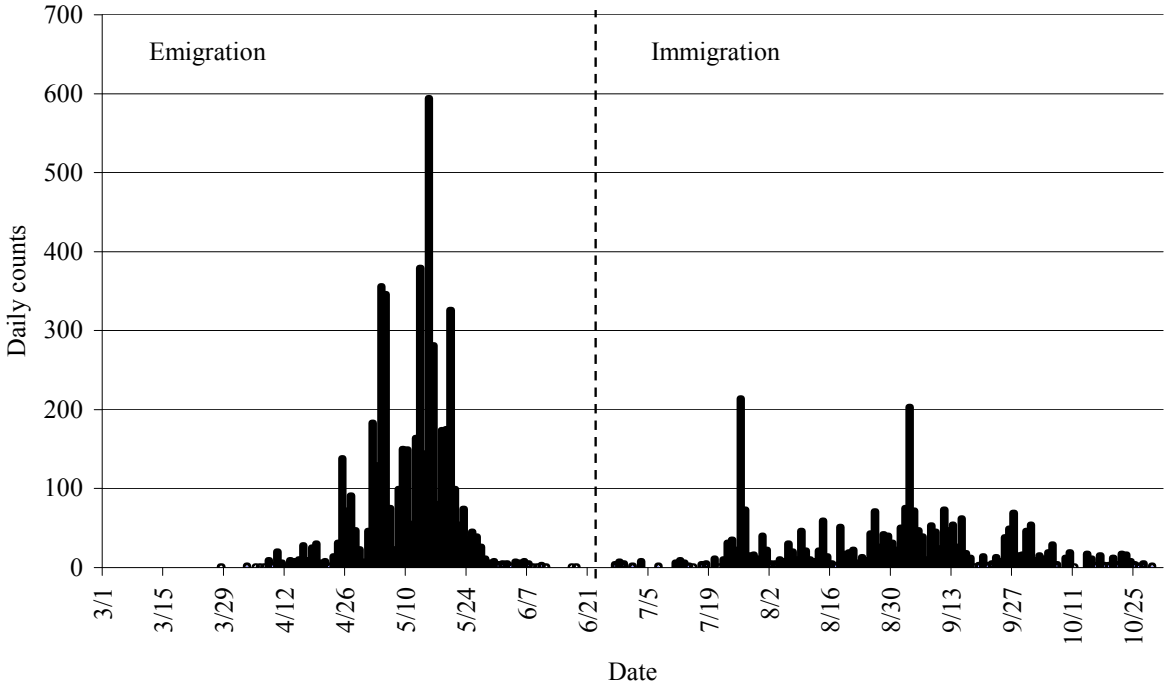

Figure 9.–Emigration and immigration counts of Dolly Varden at Auke Creek in 2006.

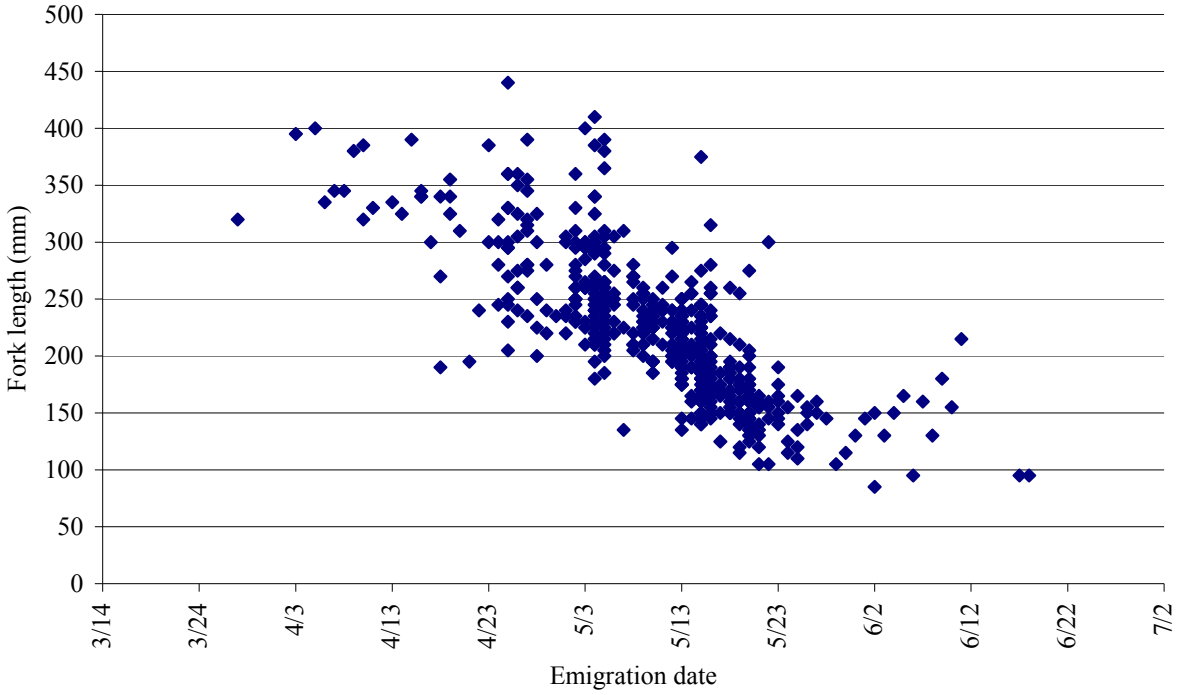

Figure 10.–Dolly Varden lengths versus date during the spring emigration at Auke Creek in 2006.

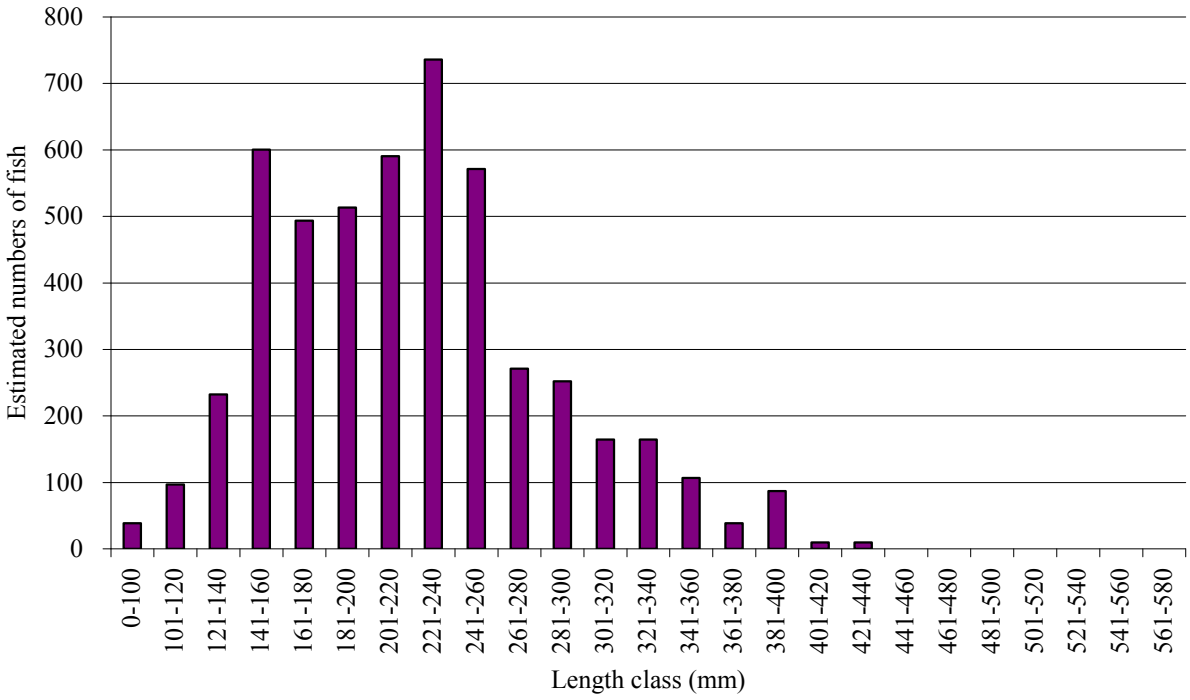

Figure 11.–Estimated length composition of emigrating Dolly Varden at Auke Creek in 2006.

Table 3.–Length composition and estimated abundance-at-length for emigrating Dolly Varden at Auke Creek in 2006. Number sampled (n_ℓ), proportion ($\hat{p}_\ell$), abundance ($\hat{N}_\ell$), and standard error (SE) are shown for each 20-mm length class.

Length, mm FL	n_ℓ	$\hat{p}_\ell$	SE($\hat{p}_\ell$)	$\hat{N}_\ell$	SE($\hat{N}_\ell$)
< 100	4	0.01	0.00	39	19
101–120	10	0.02	0.01	97	30
121–140	24	0.05	0.01	232	46
141–160	62	0.12	0.01	600	72
161–180	51	0.10	0.01	494	66
181–200	53	0.10	0.01	513	67
201–220	61	0.12	0.01	591	71
221–240	76	0.15	0.02	736	78
241–260	59	0.11	0.01	571	70
261–280	28	0.05	0.01	271	50
281–300	23	0.05	0.01	252	48
301–320	17	0.03	0.01	165	39
321–340	17	0.03	0.01	165	39
341–360	11	0.02	0.01	107	32
361–380	4	0.01	0.00	39	19
381–400	9	0.02	0.01	87	29
401–420	1	0.00	0.00	9	10
421–440	1	0.00	0.00	9	10
441–460	0	0.00	0.00	0	0
461–480	0	0.00	0.00	0	0
481–500	0	0.00	0.00	0	0
n =	514		N = 4,977		

were captured in 2006. This was the forth highest count recorded since 1980 and is more than the 26-year historical average of 16,927 (Table 1).

ESCAPEMENT, AGE, SEX AND LENGTH

The jack coho salmon immigration began on September 2, ended on October 22 (Appendix A2), and the midpoint was September 15. A total of 135 coho jacks were counted at the weir in 2006, 50 of which were sampled. The estimated age composition of jacks was 35% age 1.0 and 66% age 2.0 (Table 5). About 20% of the scales sampled were not readable. The average length was 295 mm MEF (SE = 5 mm) for age-1.0 jacks, and 321 mm MEF (SE = 5 mm) for age-2.0 fish (Table 6).

The adult coho salmon immigration began on August 26, ended on October 16 (Appendix A2), and the midpoint was September 20. This starting date is skewed, however, as many fish captured at the weir early in the immigration were not ready to remain in freshwater, so they were placed back downstream without being enumerated. There is no way to avoid this as releasing fish above the weir too early results in high mortality. A total of 582 coho adults were counted at the weir in 2006, 340 of which were sampled for sex, length, and scales. This number of immigrants is less than the 26-year historical average of 721 (Table 1).

The estimated age composition of adults was 54% age-1.1 and 46% age-2.1 (Table 7). About 21% of the total scales sampled were not readable. Based on visual examination to determine sex, an estimated 49% of adult coho salmon were male and 51% were female (Table 7). Estimates of sex

Table 4.–Estimated freshwater age composition and abundance, and mean length and weight-at-age of coho salmon smolt emigrating from Auke Creek in 2006.

	Brood year and freshwater age			
	2004	2003	2002	
	Age-1.	Age-2.	Age-3.	All smolt
n	174	111	0	285
Age composition	0.556	0.444		
SE (age composition)	0.023	0.023		
Abundance	2,510	2,005	0	4515
SE (abundance)	106	106		0
n	174	111	0	289
Mean length (mm FL)	104.8	127.7		115.1
SE (mean length)	0.7	1.1		0.9
n	174	111	0	289
Mean weight. (g)	11.1	19.8		15.0
SE (mean weight)	0.21	0.64		0.38

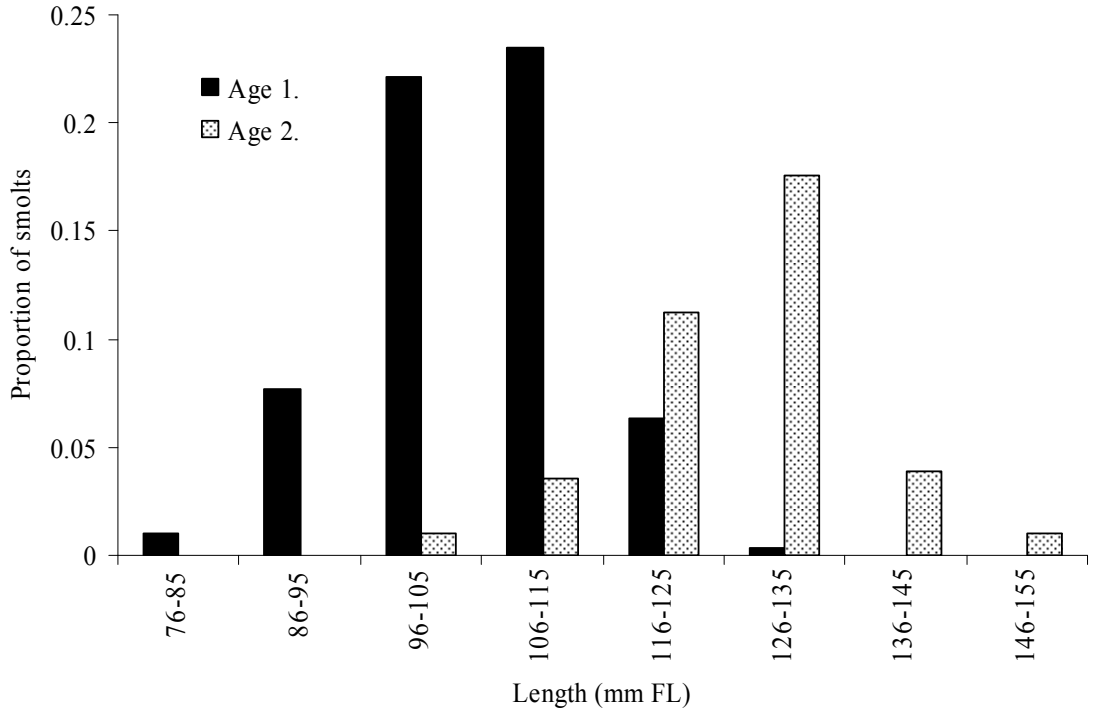

Figure 12.–Length distribution of coho salmon smolts sampled at Auke Creek in 2006.

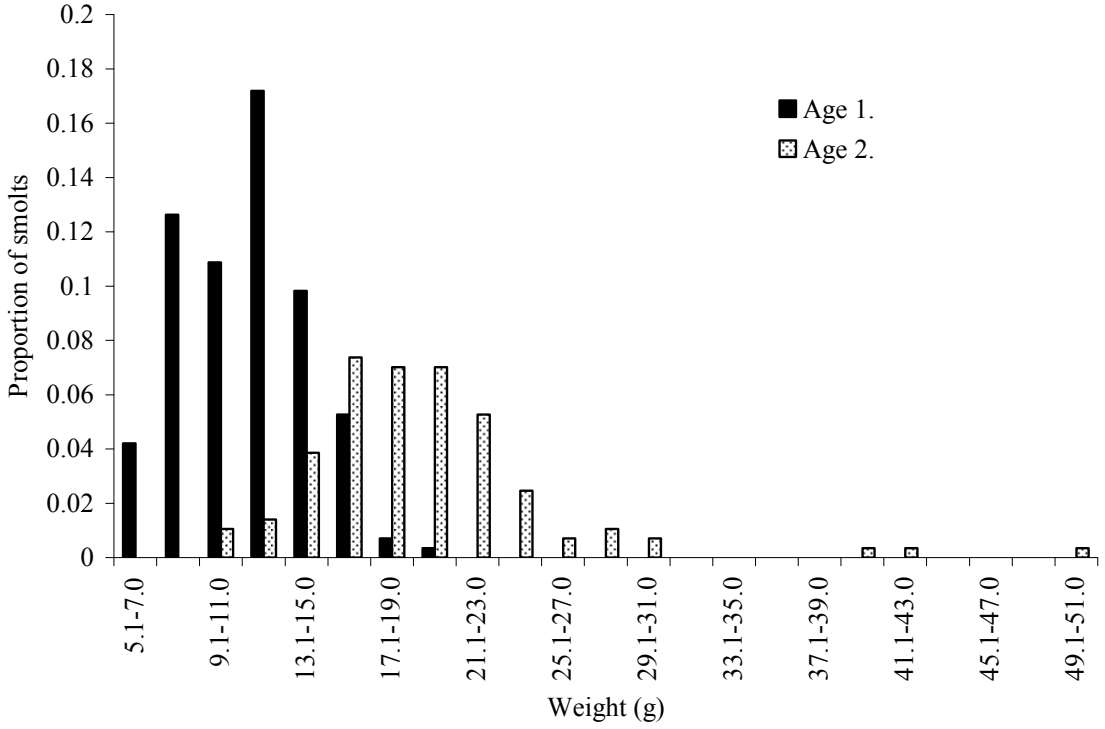

Figure 13.–Weight distribution of coho salmon smolts sampled at Auke Creek in 2006**.**

Table 5.–Estimated age composition and abundance of jack coho salmon returning to Auke Creek in 2006.

	Brood year and age class			
	2004	2003	2002	
	1.0	2.0	3.0	All
n	13	27	0	50
Fraction male	1.0	1.0		1.0
n	13	27	0	40
Age composition	0.34	0.66		
SE (age composition)	0.07	0.07		
Escapement	47	88	0	135
SE (escapement)	9	9		0

Table 6.–Estimated mean length-at-age of jack coho salmon returning to Auke Creek in 2006.

	Brood year and age class			
	2004	2003	2002	
	1.0	2.0	3.0	All
n	13	27	0	50
Mean length (mm MEF)	295	321	0.0	319
SE (mean length)	5	5	0.0	4.7

Table 7.–Estimated age and sex composition and abundance of adult coho salmon returning to Auke Creek in 2006.

	Brood year and age class			
	2003	2002	2001	
	1.1	2.1	3.1	All
All Fish				
n	142	127	0	269
Age composition	0.54	0.46		
SE (age composition)	0.03	0.03		
Escapement	315	267	0	582
SE (escapement)	15	15		0
Male				
n	76	56	0	169
Fraction male	0.53	0.43		0.49
SE (fraction male)	0.04	0.04		0.02
Escapement	166	115	0	284[a]
SE (escapement)	14	12		13[a]
Female				
n	66	71	0	171
Fraction female	0.47	0.57		0.51
SE (fraction female)	0.04	0.04		0.02
Escapement	149	152	0	298[a]
SE (escapement)	14	13		13[a]

[a] Sex composition based on all fish sexed differs from that based on aged fish. Thus, total numbers by sex differ from totals based on sums by sex over age.

Table 8.–Estimated mean length-at-age by sex of adult coho salmon returning to Auke Creek in 2006.

	Brood year and age class			
	2003	2002	2001	All
	1.1	2.1	3.1	Adults
All Fish				
n	142	127	0	340
Mean length (mm MEF)	615	619		615
SE (mean length)	3	3		2
Male				
n	76	56	0	169
Mean length (mm MEF)	611	623		614
SE (mean length)	5	4		47
Female				
n	66	71	0	171
Mean length (mm MEF)	620	616		616
SE (mean length)	2	4		2

composition based on summing abundance by sex at age are slightly different (48% male, 52% female) because sex composition of all fish sampled varied slightly from that for aged fish. The average length for all adult coho salmon sampled was 615 mm MEF (SE = 2 mm), 615 mm MEF (SE = 3 mm) for age-1.1 fish, and 619 mm MEF (SE = 3) for age-2.1 fish (Table 8; Figure 14). Females averaged 616 mm MEF (SE = 2 mm) and males averaged 614 mm MEF (SE = 4 mm; Table 8, Figure 15).

The adult sockeye salmon immigration began on June 26, ended on September 15, 2006 (Appendix A2), and the midpoint was July 26. A total of 1,848 sockeye adults and 20 jacks were counted at the weir. This is less than the 26-year historical average of 3,399 adults (Table 1) and is the eighth lowest count seen since 1963.

MARINE HARVEST, TOTAL ABUNDANCE, MARINE SURVIVAL & EXPLOITATION

A total of 80 Auke Creek coded wire tags were recovered from commercial fisheries in 2006, and 7 CWTs were recovered from sport fisheries during this same time (Appendix B1). An estimated 313 (SE = 30) Auke Creek adult coho salmon were harvested in 2006 (Appendix B1). Combining this harvest with the number counted at the weir yielded a total return of 895 (SE = 30) adults.

Coho salmon smolt-to-adult marine survival at Auke Creek was estimated to be 21% (SE = 0.7%) for all coho tagged in 2005 (4,287;ADF&G 2006).

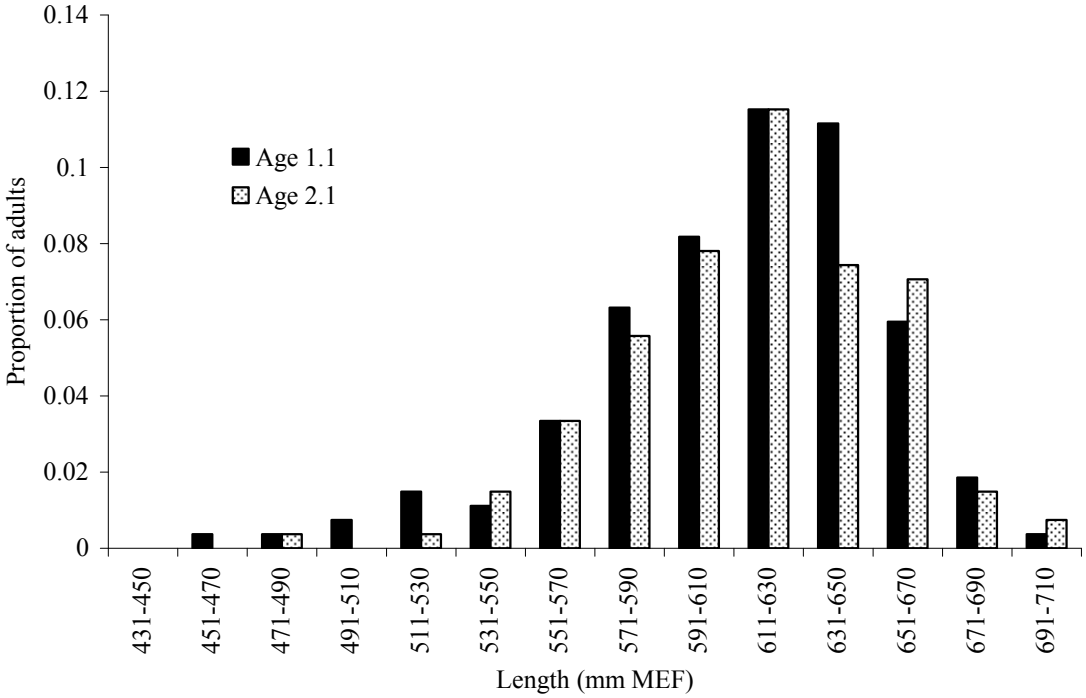

Figure 14.–Length distribution by age of adult coho salmon at Auke Creek in 2006.

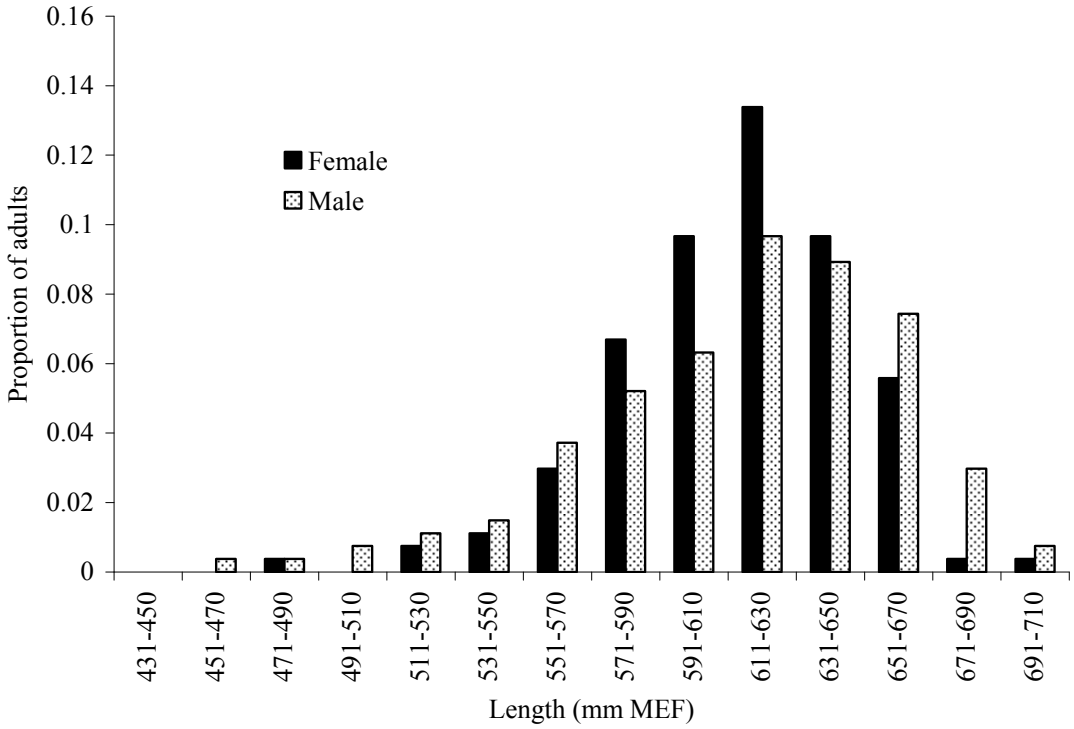

Figure 15.–Length distribution by sex of adult coho salmon at Auke Creek in 2006.

The exploitation rate of Auke Creek coho salmon was estimated to be 35% (SE = 2.2%) in 2006 marine fisheries.

OTHER SPECIES

Pink salmon fry began their emigration from Auke Creek on March 2, 2006. The migration lasted through June 11 (Appendix A1) and its midpoint was May 26. A total of 65,894 pink salmon fry were counted, and this is less than the 26-year historical average of 107,834 (Table 1). Pink salmon adults began their immigration on July 23, and the migration lasted through September 21 (Appendix A2). The midpoint of immigration was August 18, and 13,198 pink salmon adults were seen. Of these, 52% (SE = 0.48%) were estimated to be male and 48% (SE = 0.52%) were female.

Chum salmon fry began emigrating on March 13, 2006. The migration lasted through June 13 (Appendix A1), its midpoint was May 24, and a total of only 87 chum salmon fry were seen. This is much less than the 26-year historical average of 4,786 (Table 1) and is the third lowest number of fish seen during that time. Chum salmon adults began their immigration on July 20 and the migration lasted through September 12 (Appendix A2). The midpoint of immigration was August 2, and 6,623 chum salmon adults were seen. This count is more than five times the 26-year historical average of 1,244 (Table 1).

Juvenile steelhead were seen during both the emigration and immigration periods in 2006. A total of 36 steelhead emigrated from Auke Lake beginning on May 16 and ending on June 7 (Appendix A1), and a total of 8 immigrated to the lake beginning on September 16 and ending on October 17 (Appendix A2). The spring emigration count of 36 is the highest number of juvenile steelhead seen at the Auke Creek weir.

STREAM TEMPERATURE

Water temperatures at the Auke Creek weir throughout 2006 ranged from 0.1°C to 19.4°C (mean = 7.3°C). During the emigration period temperatures ranged from 0.2°C to 19.4°C (mean = 7.2°C, Appendix A1), and during immigration temperatures were between 6.2°C and 18.6°C (mean = 12.8°C, Appendix A2).

DISCUSSION

The general downward trend of emigrant cutthroat trout and Dolly Varden observed at the Auke Creek weir since the late 1990s continued during 2006. However, both the cutthroat trout and Dolly Varden emigrant counts were slightly higher than the previous 2 years, but still below the 1980–2005 average. On average there were 43 fewer cutthroat trout emigrants when compared to the 1980–2005 average of 251, and 1,135 fewer Dolly Varden emigrants compared to the 1980–2005 average of 6,110. Auke Lake is one of the primary overwintering lakes for both cutthroat trout and Dolly Varden in the Juneau area. Cutthroat trout emigrants from Auke Lake are known to disperse and believed to spawn in at least 10 streams in the Juneau area (Jones and Seifert 1997). Various Dolly Varden tagging studies provide evidence that Juneau area Dolly Varden utilize Auke Lake during several life stages and that Auke Lake emigrants contribute to the Juneau area and northern Southeast Alaska sport fisheries (Neimark 1984b; Bernard et al. 1995; Jones and Harding 1998).

The Auke Creek weir counts of both emigrant and immigrant coho salmon during 2006 continued to trend downwards, while the sockeye salmon emigrant count was above the 1980–2006 average by approximately 48%. The number of adult sockeye salmon returning to the Auke system however, was the lowest in 7 years. While the exact reasons for the declines in coho salmon emigrants is unknown, two hypotheses involve the addition of hydrocarbons by watercraft (Rice et al. 2008) and changing streambed and flow characteristics of Lake Creek (Hoover 2007).

The decline in the total number of adult coho salmon returning to Auke Creek was mirrored in nearby Berners River and may have been more widespread in other inland streams of northern Southeast Alaska. While the total return of Auke Creek coho salmon was 69% of the 1982–2005 average, the decline in adult coho return to Berners River was 52% of the 1982–2005 average (Shaul et al. *In prep).*

The information garnered from the Auke Creek weir and Auke Lake system is invaluable. The long and complete historical data set about

abundance, survival, growth, migration timing, and other life history information for the species present in this system is widely regarded as the most complete on the entire West Coast. Results of the project contribute to other research efforts on the system, help guide management decisions and planning, and enable long-term monitoring as urban development in the area continues.

ACKNOWLEDGMENTS

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APPENDIX A

Appendix A1.–Daily count of spring emigrants at Auke Creek, 2006.

	Cutthroat Trout	Dolly Varden	Sockeye Smolt	Pink Fry	Chum Fry	Coho Smolt	Juvenile Steelhead	Water Temp
March 1	0	0	0	0	0	0	0	1.3
2	0	0	0	11	0	0	0	1.2
3	0	0	0	11	0	0	0	1.4
4	0	0	0	15	0	0	0	1.4
5	0	0	0	12	0	0	0	1.4
6	0	0	0	32	0	0	0	1.4
7	0	0	0	28	0	0	0	1.4
8	0	0	0	29	0	0	0	1.4
9	0	0	0	99	0	0	0	1.4
10	0	0	0	41	0	0	0	1.3
11	0	0	0	32	0	0	0	1
12	0	0	0	35	0	0	0	1.1
13	0	0	0	64	1	0	0	0.7
14	0	0	0	16	0	0	0	0.3
15	0	0	0	11	0	0	0	0.2
16	0	0	0	16	0	0	0	0.2
17	0	0	0	19	0	0	0	0.2
18	0	0	0	36	0	0	0	0.5
19	0	0	0	19	0	0	0	0.9
20	0	0	0	34	0	0	0	1.5
21	0	0	0	37	0	0	0	1.5
22	0	0	0	55	0	0	0	1.5
23	0	0	0	31	0	0	0	1.6
24	0	0	0	33	0	0	0	1.9
25	0	0	0	41	0	0	0	2
26	0	0	0	53	0	0	0	2.2
27	0	0	0	85	0	0	0	2.3
28	0	1	0	151	0	0	0	2.4
29	0	0	0	186	0	0	0	2.5
30	0	0	0	274	0	0	0	2.6
31	0	0	0	314	0	0	0	2.6
April 1	0	0	0	449	1	0	0	2.7
2	0	0	0	370	0	0	0	3
3	0	2	0	545	2	0	0	3
4	0	0	0	347	0	0	0	3.1
5	0	1	0	472	0	0	0	3.2
6	0	1	0	715	0	0	0	3.2
7	0	1	0	4,724	0	0	0	3.4
8	0	9	0	3,059	1	0	0	3.5
9	1	3	0	3,642	0	0	0	3.6
10	0	20	0	4,114	2	0	0	3.7
11	0	6	0	3,777	1	0	0	3.8
12	0	0	0	4,411	0	0	0	3.8
13	0	9	0	4,176	2	0	0	3.8
14	0	8	0	3,640	0	0	0	3.8
15	0	10	0	3,007	2	0	0	3.7
16	0	28	0	5,815	2	0	0	4
17	0	9	0	2,307	0	0	0	4
18	3	25	0	2,276	1	0	0	4.1
19	0	30	0	3,407	0	0	0	4.1

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Appendix A1.–Page 2 of 3.

	Cutthroat Trout	Dolly Varden	Sockeye Smolt	Pink Fry	Chum Fry	Coho Smolt	Juvenile Steelhead	Water Temp
April 20	0	6	0	1,552	0	0	0	4.2
21	0	8	0	2,101	0	0	0	4.2
22	0	2	0	2,008	0	0	0	4.5
23	0	14	0	2,635	2	0	0	4.6
24	1	31	0	1,372	2	0	0	4.7
25	3	138	0	845	1	0	0	4.8
26	2	72	0	278	1	0	0	5.1
27	0	91	0	541	1	0	0	5.7
28	4	47	0	331	0	0	0	5.3
29	1	23	1	198	3	0	0	5.2
30	1	7	0	174	1	0	0	5.1
May 1	1	46	2	186	0	0	0	5.1
2	3	183	3	62	1	0	0	5.4
3	2	129	2	68	2	0	0	5.4
4	3	356	4	71	0	2	0	5.4
5	2	346	9	117	0	4	0	5.2
6	0	75	7	44	0	2	0	5.4
7	0	23	3	85	2	2	0	5.3
8	4	99	5	21	0	5	0	5.4
9	0	150	6	25	0	3	0	5.4
10	0	149	3	10	0	5	0	5.5
11	0	55	2	7	0	3	0	5.6
12	1	164	3	12	0	2	0	6.3
13	4	379	2	17	1	20	0	6.4
14	2	144	11	15	3	18	0	7.5
15	2	594	25	7	0	25	0	8.1
16	1	281	112	9	0	33	1	8.4
17	2	80	32	5	0	39	4	8.9
18	7	174	94	5	0	90	4	8.9
19	3	175	110	3	0	172	1	8.8
20	9	326	1,189	6	1	561	2	9.3
21	10	99	1,268	3	1	440	2	10.4
22	5	54	945	1	2	258	2	12
23	12	74	1,156	1	3	286	2	13
24	9	35	3,018	1	3	370	0	13.2
25	14	45	3,177	0	2	375	5	14.2
26	8	39	3,766	0	5	290	6	15.8
27	21	26	3,511	0	3	219	1	16.6
28	10	11	2,180	0	1	125	1	16.4
29	3	6	1,543	0	3	215	1	15.9
30	5	8	903	0	2	125	0	16.1
31	4	4	772	0	2	89	1	15.9
June 1	5	5	391	0	1	68	0	16
2	3	5	179	0	0	68	0	16
3	12	2	186	0	1	75	2	14.6
4	10	7	201	0	3	109	0	13.9
5	1	6	147	4	3	105	0	13.8
6	2	8	130	0	3	90	0	13.5
7	1	5	144	0	5	69	1	13.5
8	5	1	83	0	1	47	0	14.1

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Appendix A1.–Page 3 of 3.

	Cutthroat Trout	Dolly Varden	Sockeye Smolt	Pink Fry	Chum Fry	Coho Smolt	Juvenile Steelhead	Water Temp
June 9	3	1	78	0	3	27	0	15.6
10	1	3	35	0	2	30	0	17
11	0	1	22	1	1	16	0	17.8
12	0	0	39	0	0	20	0	18.7
13	0	0	7	0	1	7	0	18.9
14	0	0	2	0	0	11	0	19.4
15	1	0	1	0	0	3	0	19
16	0	0	1	0	0	3	0	18.6
17	1	1	0	0	0	1	0	18.1
18	0	1	0	0	0	0	0	17.2
19	0	0	1	0	0	2	0	16.5
20	0	0	2	0	0	0	0	16.5
21	0	0	2	0	0	2	0	16.5
22	0	0	0	0	0	1	0	15.3
Totals	208	4,977	25,515	65,894	87	4,532	36	

Appendix A2.–Daily count of summer/fall immigrants at Auke Creek, 2006.

	Cutthroat Trout	Dolly Varden	Sockeye Adults	Pink Adults	Chum Adults	Coho Adults	Coho Jacks	Juvenile Steelhead	Water Temp
June 22	0	0	0	0	0	0	0	0	15.3
23	0	0	0	0	0	0	0	0	15
24	0	0	0	0	0	0	0	0	15.2
25	0	0	0	0	0	0	0	0	14.8
26	0	0	16	0	0	0	0	0	14.1
27	0	4	17	0	0	0	0	0	14.4
28	0	7	21	0	0	0	0	0	14.5
29	0	5	2	0	0	0	0	0	14.8
30	0	0	4	0	0	0	0	0	15.1
July 1	0	2	5	0	0	0	0	0	15.2
2	0	0	0	0	0	0	0	0	15.1
3	0	8	0	0	0	0	0	0	16.3
4	0	0	0	0	0	0	0	0	17.4
5	0	0	0	0	0	0	0	0	18
6	0	0	0	0	0	0	0	0	18.6
7	0	2	0	0	0	0	0	0	18.2
8	0	0	0	0	0	0	0	0	17.7
9	0	0	0	0	0	0	0	0	17.3
10	0	0	0	0	0	0	0	0	16.7
11	0	6	42	0	0	0	0	0	17.6
12	0	9	11	0	0	0	0	0	18.1
13	0	6	32	0	0	0	0	0	17.7
14	0	2	68	0	0	0	0	0	17
15	0	1	30	0	0	0	0	0	16.5
16	0	0	8	0	0	0	0	0	16.3
17	0	4	0	0	0	0	0	0	16.4
18	0	5	114	0	0	0	0	0	16.5
19	0	0	52	0	0	0	0	0	16.7
20	0	11	13	0	3	0	0	0	17.4
21	0	1	0	0	2	0	0	0	16.7
22	0	10	79	0	30	0	0	0	16.9
23	0	31	51	1	42	0	0	0	17.2
24	0	35	15	0	74	0	0	0	16.8
25	0	22	70	0	284	0	0	0	16.4
26	0	214	321	43	818	0	0	0	15.9
27	0	73	163	49	473	0	0	0	15.5
28	0	15	88	5	461	0	0	0	15.6
29	0	16	7	1	71	0	0	0	17.3
30	0	11	7	6	68	0	0	0	17.2
31	0	40	3	14	185	0	0	0	16.2
August 1	0	22	6	20	497	0	0	0	15.6
2	0	5	10	0	383	0	0	0	15.3
3	0	5	15	28	472	0	0	0	15.1
4	0	10	59	68	382	0	0	0	15.2
5	0	8	69	286	282	0	0	0	14.3
6	0	30	230	756	286	0	0	0	14

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Appendix A2.–Page 2 of 3.

	Cutthroat Trout	Dolly Varden	Sockeye Adults	Pink Adults	Chum Adults	Coho Adults	Coho Jacks	Juvenile Steelhead	Water Temp
August 7	0	20	47	949	277	0	0	0	13.8
8	0	10	10	471	198	0	0	0	14.1
9	0	46	28	360	108	0	0	0	13.5
10	0	21	20	623	100	0	0	0	13.5
11	0	10	4	297	56	0	0	0	13.6
12	0	8	4	151	35	0	0	0	13.3
13	0	21	9	270	58	0	0	0	13.1
14	0	59	12	1,164	99	0	0	0	13.2
15	0	14	3	321	63	0	0	0	13.6
16	0	5	4	167	47	0	0	0	13.6
17	0	3	3	182	53	0	0	0	13.3
18	0	51	10	541	83	0	0	0	12.5
19	0	17	6	580	129	0	0	0	13.3
20	0	19	3	258	76	0	0	0	13.6
21	0	22	2	309	80	0	0	0	13.5
22	0	6	4	74	32	0	0	0	13.5
23	0	13	1	165	46	0	0	0	13.7
24	0	9	7	274	47	0	0	0	13.5
25	0	43	7	535	78	0	0	0	12.8
26	0	71	4	801	27	1	0	0	12.9
27	0	26	6	373	23	0	0	0	12.9
28	0	42	2	247	22	0	0	0	13
29	0	40	1	131	12	0	0	0	12.9
30	0	31	0	61	4	0	0	0	13
31	0	22	0	104	4	0	0	0	13
September 1	0	50	2	818	4	0	0	0	12.1
2	0	75	7	662	6	0	4	0	11.9
3	0	203	2	474	19	0	1	0	12.5
4	0	72	0	116	14	0	0	0	13.4
5	0	47	1	109	7	0	1	0	13.2
6	0	39	2	64	2	0	3	0	13.3
7	0	10	0	49	0	0	0	0	12.8
8	0	53	1	85	0	74	5	0	12.8
9	0	45	1	49	0	0	5	0	12.4
10	0	24	0	0	0	0	0	0	12
11	0	73	3	16	0	63	13	0	11.9
12	0	47	2	23	1	55	12	0	11.9
13	0	54	0	13	0	44	15	0	11.7
14	8	26	0	18	0	8	6	0	12.1
15	12	62	2	11	0	11	3	0	11.6
16	10	18	0	2	0	6	3	3	11.6
17	3	12	0	0	0	0	5	0	11.6
18	4	1	0	2	0	2	5	0	11.5
19	2	3	0	0	0	1	1	0	11.3
20	2	14	0	1	0	13	4	0	11
21	14	3	0	1	0	20	7	0	11.1
22	8	5	0	0	0	15	3	0	11
23	4	13	0	0	0	35	8	0	11

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Appendix A2.–Page 3 of 3.

	Cutthroat Trout	Dolly Varden	Sockeye Adults	Pink Adults	Chum Adults	Coho Adults	Coho Jacks	Juvenile Steelhead	Water Temp
September 24	0	8	0	0	0	47	3	0	11
25	16	38	0	0	0	40	4	0	10.3
26	1	49	0	0	0	39	2	0	10.8
27	4	69	0	0	0	20	3	1	10.6
28	0	15	0	0	0	14	2	0	10.5
29	1	16	0	0	0	14	0	0	10.1
30	2	46	0	0	0	19	1	0	10.1
October 1	1	54	0	0	0	14	5	1	10.1
2	1	9	0	0	0	0	1	0	9.9
3	1	15	0	0	0	2	2	0	9.8
4	1	11	0	0	0	2	1	1	9.7
5	0	19	0	0	0	10	1	0	9.4
6	1	29	0	0	0	6	1	0	9.3
7	2	4	0	0	0	0	1	0	9.2
8	0	0	0	0	0	0	0	0	8.9
9	0	12	0	0	0	0	0	0	9
10	1	19	0	0	0	0	3	0	9.2
11	0	1	0	0	0	0	0	0	9.4
12	0	0	0	0	0	0	0	0	9.2
13	0	0	0	0	0	1	0	0	8.9
14	1	17	0	0	0	2	0	1	8.8
15	4	11	0	0	0	2	0	0	8.7
16	1	3	0	0	0	2	0	0	8.6
17	0	15	0	0	0	0	0	1	8.3
18	1	3	0	0	0	0	0	0	8.2
19	0	3	0	0	0	0	0	0	8.2
20	0	12	0	0	0	0	0	0	8.4
21	0	4	0	0	0	0	0	0	8.3
22	0	17	0	0	0	0	1	0	8.2
23	0	16	0	0	0	0	0	0	7.9
24	0	8	0	0	0	0	0	0	7.8
25	1	4	0	0	0	0	0	0	7.6
26	0	2	0	0	0	0	0	0	7.4
27	0	5	0	0	0	0	0	0	7.1
28	0	0	0	0	0	0	0	0	6.8
29	0	2	0	0	0	0	0	0	6.4
30	0	0	0	0	0	0	0	0	6.3
31	0	0	0	0	0	0	0	0	6.2
Totals	107	2,734	1,848	13,198	6,623	582	135	8	

APPENDIX B

Appendix B1.–Harvest sampling statistics and estimated harvest of Auke Creek adult coho salmon in 2006. See key at bottom of table for key to the variables.

Fishery, quadrant	Stat. week, bi-week or (period)	N_i	n_i	a_i	a_i'	t_i	t_i'	m_{ij}	$\hat{r}_{ij}$	$\mathrm{var}(\hat{r}_{ij})$	$SE(\hat{r}_{ij})$
Drift, NE	35	12,679	4,191	46	46	40	40	2	6	12	3.5
Drift, NE	37	25,944	7,952	228	227	209	209	6	20	45	6.7
Drift, NE	38	31,134	9,860	444	443	428	428	16	51	109	10.5
Drift, NE	39	5,690	1,544	57	57	55	55	2	7	20	4.4
Troll, NW	29	112,281	27,660	267	260	190	190	3	13	39	6.2
Troll, NW	30	75,366	24,582	305	300	219	219	5	16	32	5.7
Troll, NW	31	64,694	16,964	224	220	164	164	1	4	11	3.3
Troll, NW	32	49,446	21,237	264	231	160	160	8	21	29	5.4
Troll, NW	33	77,198	15,966	198	190	156	156	5	25	100	10.0
Troll, NW	34	56,863	16,792	233	230	194	194	3	10	25	5.0
Troll, NW	35	83,261	19,017	312	301	252	251	6	27	95	9.7
Troll, NW	36	78,780	16,956	288	281	240	240	6	29	106	10.3
Troll, NE	37	14,751	1,966	28	28	16	16	1	8	49	7.0
Troll, NW	37	80,591	18,202	346	326	274	274	11	52	185	13.6
Troll, NW	38	22,982	8,849	179	179	144	144	4	10	17	4.1
Troll, NW	39	3,271	808	12	12	10	10	1	4	12	3.5
Juneau Sport	16	434	400	2	2	2	2	3	3	0	0.5
Gustavus Sport	16	4,068	4,068	40	40	30	30	1	1	0	0.0
Juneau Sport	17	2,905	1,497	22	16	15	15	1	3	2	1.4
Juneau Sport	18	1,310	623	19	19	16	16	2	4	5	2.2
Totals		803,648	219,134	3,514	3,408	2,814	2,813	87	313	892	29.9

Notes: N_i = harvest in fishery strata i; n_i = number inspected for CWTs; a_i= number missing an adipose fin; a_i'= number of heads that arrive at the lab; t_i= number of heads with CWTs detected; t_i'= number of CWTs that are dissected from heads and decoded; m_{ij}= number of CWTs with code(s) j of interest; θ_j= fraction of the cohort tagged with code(s) j of interest; r_{ij}=estimated contribution in straum i by code j.

APPENDIX C

Appendix C1.–Computer data files containing Auke Creek data for Auke Creek in 2006.

File Name	Description
AukeCohoAdAge_06.xls	Excel file which SAS program reads from and writes to for coho salmon adults sampled in 2005.
AukeCohoJkAge_06.xls	Excel file which SAS program reads from and writes to for coho salmon jacks sampled in 2005.
AukeCohoSmAge_06.xls	Excel file which SAS program reads from and writes to for coho salmon smolts sampled in 2005.
Auke_Coho_CWT.xls	List of coded-wire tags and related information used historically at Auke Creek.
AC_Historical_06.xls	Historical information for counts of all species at Auke Creek.
Auke_water_temp_06.xls	Water temperature information collected both by hand and by HOBO at Auke Creek in 2005
CT_and_SH_06.xls	Length, sex, and PIT tag codes for cutthroat trout seen in 2005. Lengths of juvenile steelhead seen in 2005.
DV_Length_Date_06.xls	Length information for Dolly Varden sampled during spring emigration in 2005.
Harvest_estimates_06_Auke.xls	Tag lab harvest expansion report and marine harvest calculations for fish caught in 2005 commercial and recreational fisheries.
Length_Composition_06.xls	Length composition and calculations for Dolly Varden emigrants in 2005.
Scale_sampling_06.xls	Age, weight and length of coho salmon smolts, adults, and jacks sampled in 2005.
Scale_temp_06.xls	Graphs and additional work done with Scale_sampling_05.xls.
Strat Age Len Wt Sex.sas	SAS program used to analyze data from coho salmon adults, jacks, and smolts sampled in 2005.
Weir_Counts_06.xls	Emigrant and immigrant counts of all species seen at Auke Creek in 2005.